

**High Performance
Software Defined Radio
The Next Generation**

Dan Quigley - N7HQ

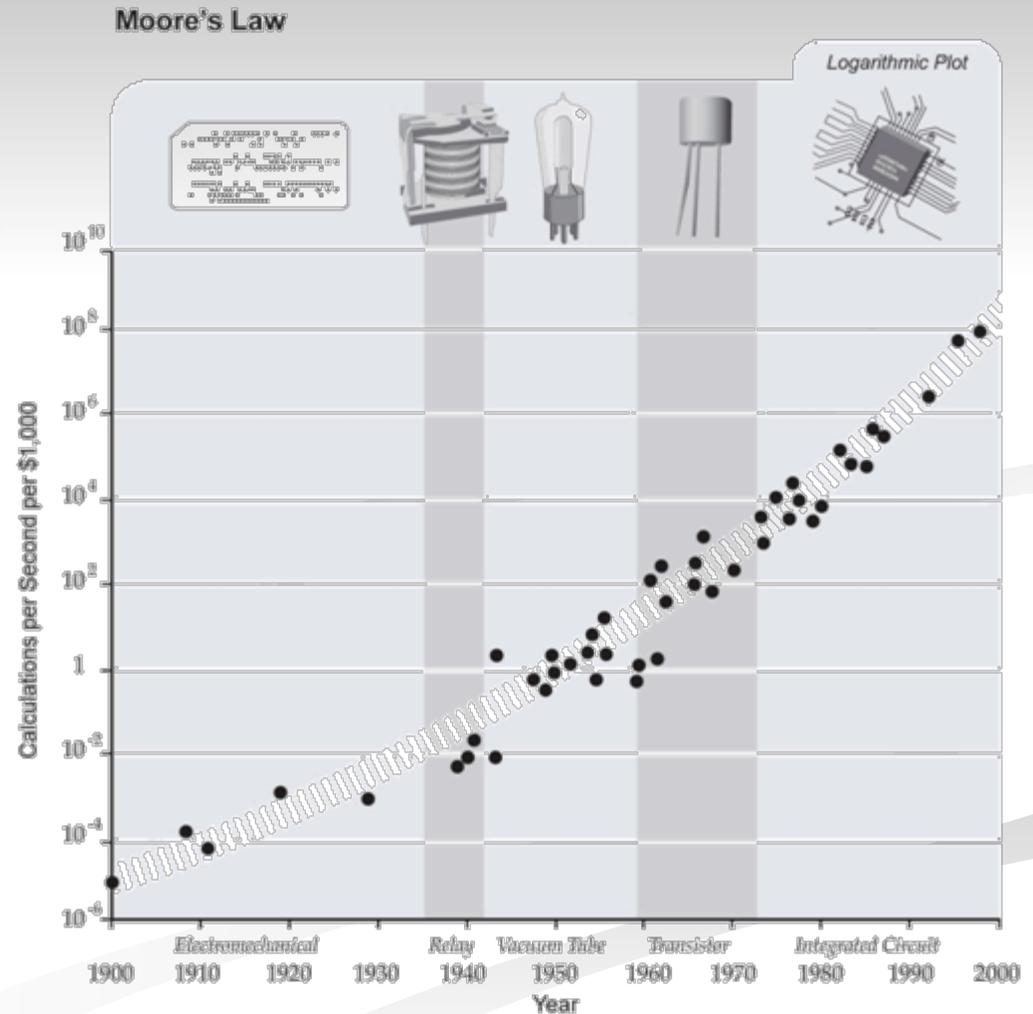
Looks Like This!



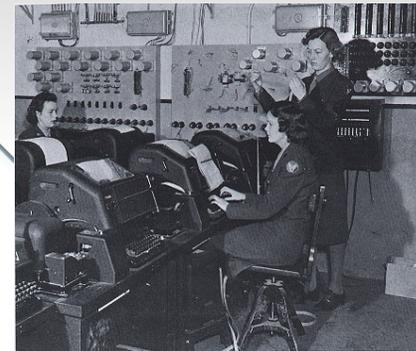
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Radio Follows Moore's Law Too

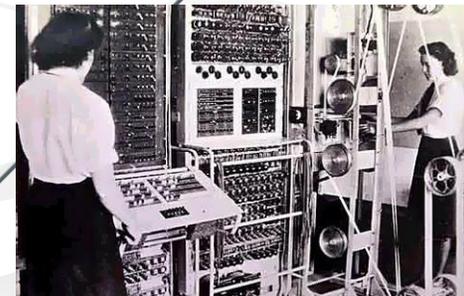
- First 50 Years
 - Electro Mechanical
 - Vacuum Tube
- Second 50
 - Transistor
 - IC
- Next... ?



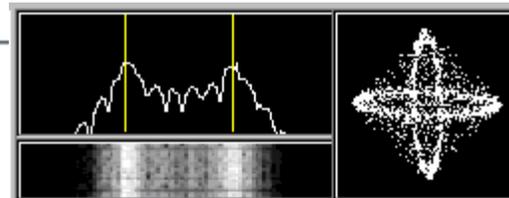
No Software



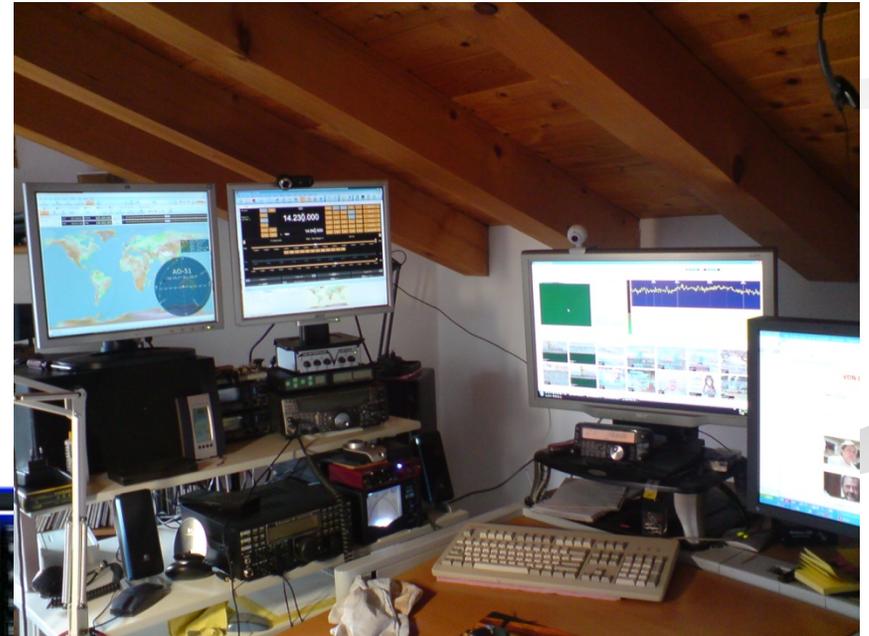
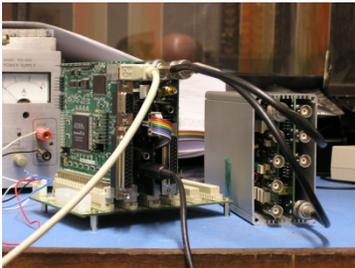
WACs assigned to the Eighth Air Force in England operate teletype machines. (DOD photograph)



Peripheral Software

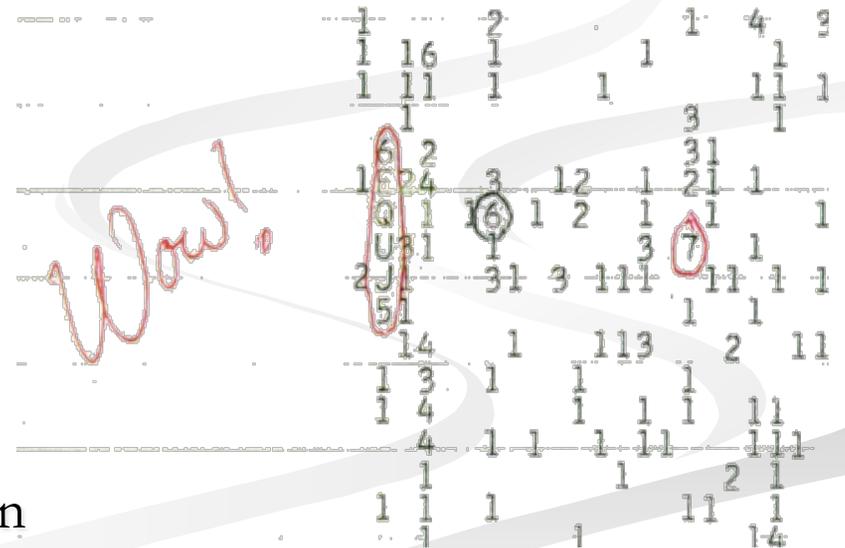


Integrated!



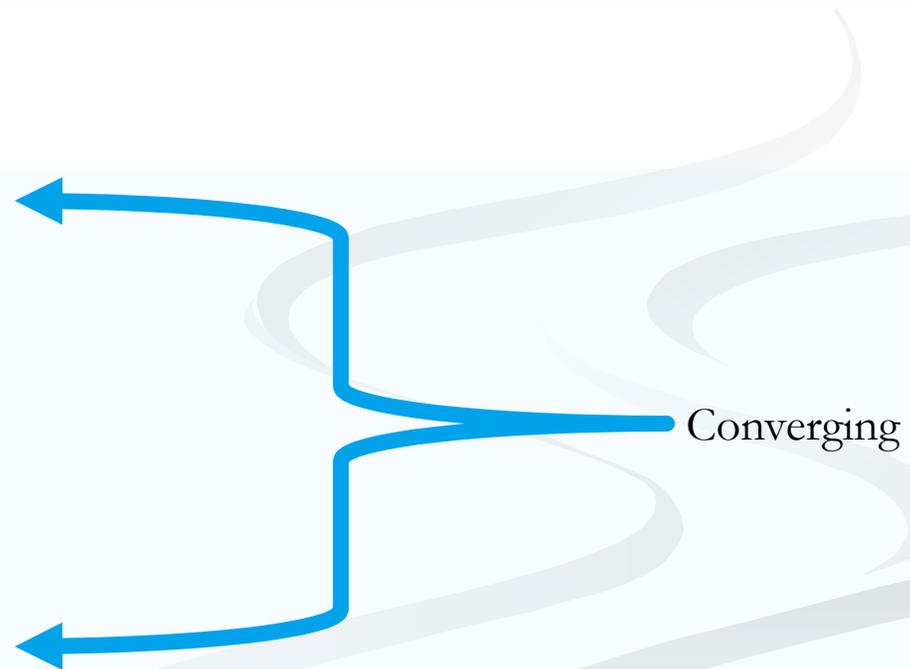
Software and Amateur Radio

- No Software
 - Marconi – Today!
- Peripheral
 - “Digital” Modes
 - Signal Analysis and Decoding
 - 1977 ... “The Wow! Signal”
 - Station Automation
 - Audio DSP
- Integrated
 - IF/RF DSP
 - The Software is the Radio
 - Personalization/Customization



Amateur Radio Software Domains

- Housekeeping and Convenience
 - Logging and Contest
 - Web-based (e.g. DX Spots, QRZ)
- Engineering
 - CAD
 - Antenna Design
 - Propagation
- Control and Automation
 - Station Control
 - Remote Stations
- Signal Processing
 - DSP
 - Data and Voice
 - Spectrum
- Software Defined Radio
 - Software is the Radio
- Individualized (Custom) Software

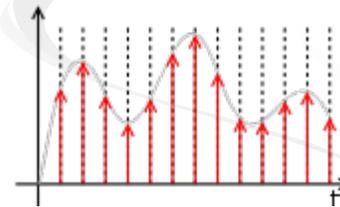
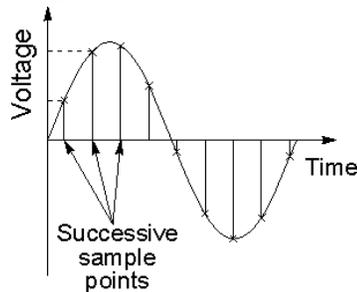
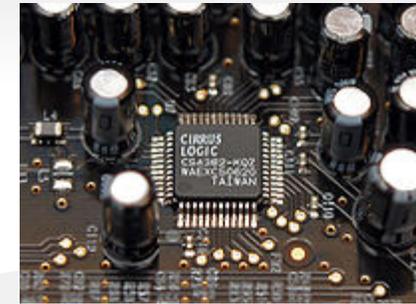


Control and Automation

- Software Driven Radio
 - CAT – Computer (Aided/Automation) Technology
 - Direct Control
 - Scanner Memories
 - Usually RS-232, USB or other serial protocol
 - Ethernet emerging as control endpoint
- Other Shack Equipment
 - Antennas and Antenna Rotors
 - Keyers
 - General Switching

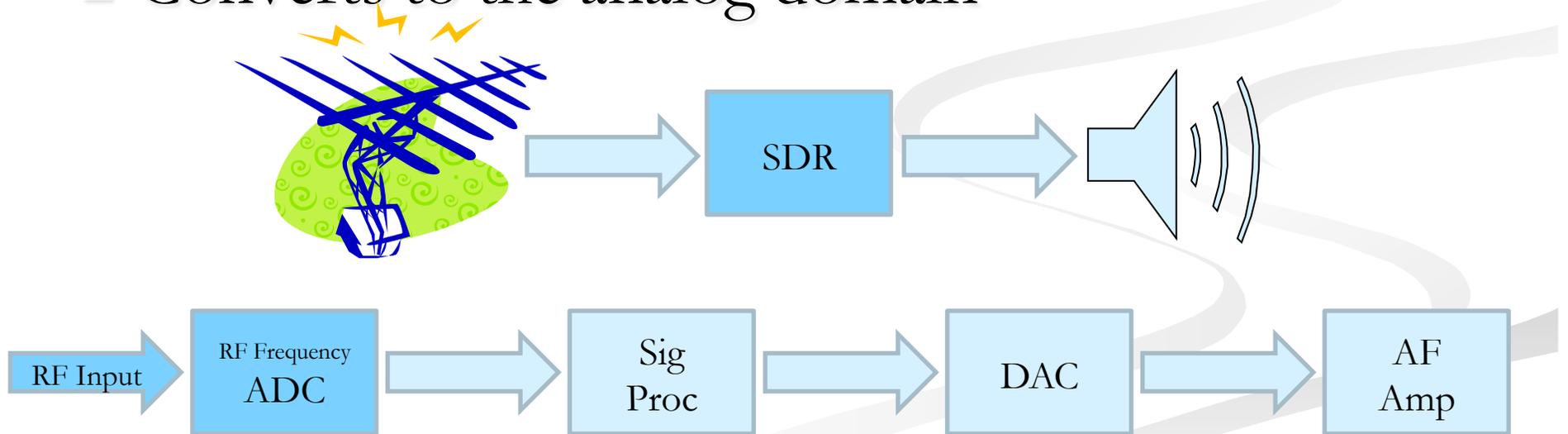
Digital Signal Processing

- Converts signal to the digital domain
- Analyzes and Processes the data
- Converts back to the analog domain
- Upgrade: AF to IF



The Ideal (Digital) Radio

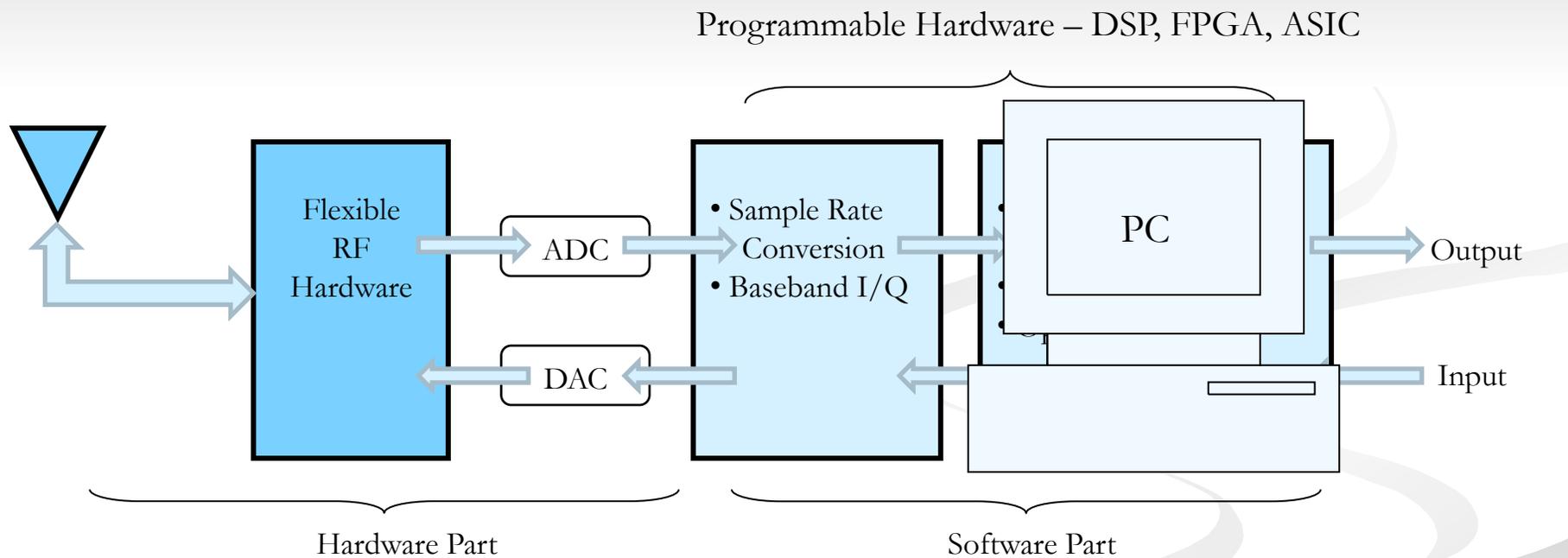
- Direct RF Conversion (zero IF)
- Signal analysis and processing
- Converts to the analog domain



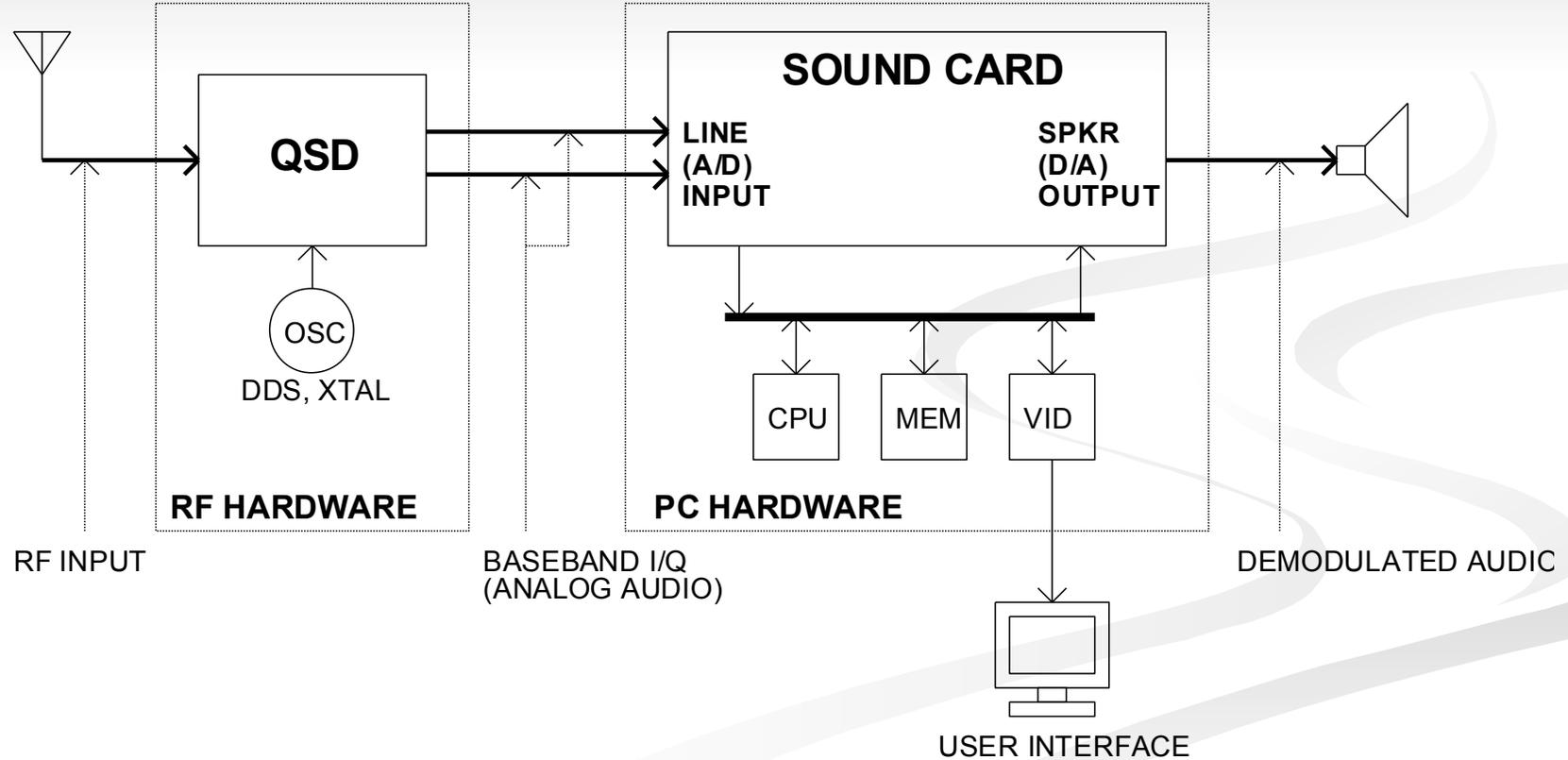
Software Defined Radio (SDR)

- Radio Functionality defined in *Software*
- Reprogrammable and Reconfigurable
- Hardware Performs *different* functions at *different* times
- Supports broad range of frequencies and modulations
- Physical layer behavior is significantly altered through changes in its software
- Best Known Examples:
 - FlexRadio Systems (SDR-1000, 3000, 5000)
 - Tony Parks (KB9YIG) SoftRock series
 - Wonder Radio
 - HPSDR (High Performance Software Defined Radio)

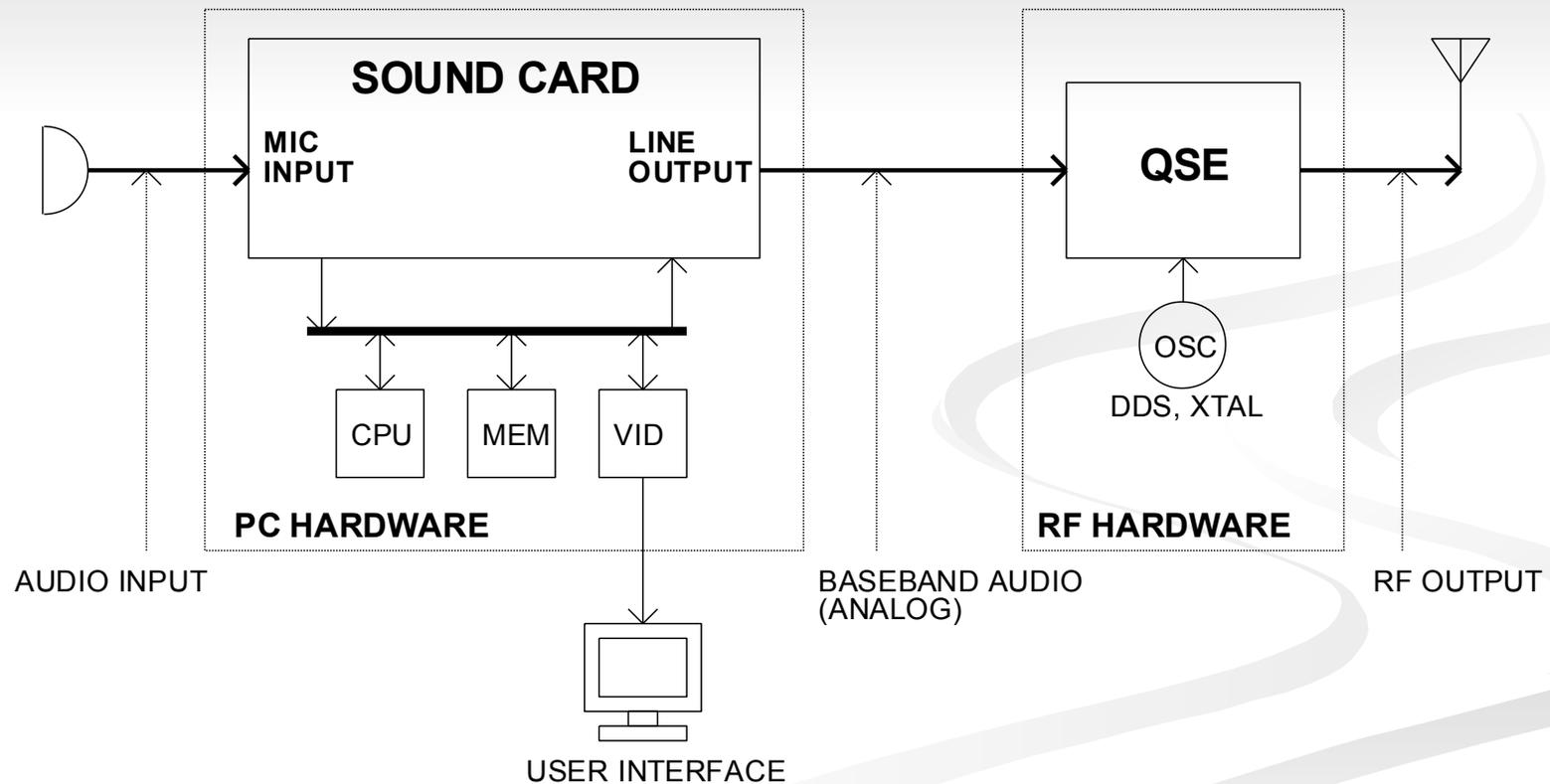
SDR Architecture



Early SDR Receiver



Early SDR Exciter

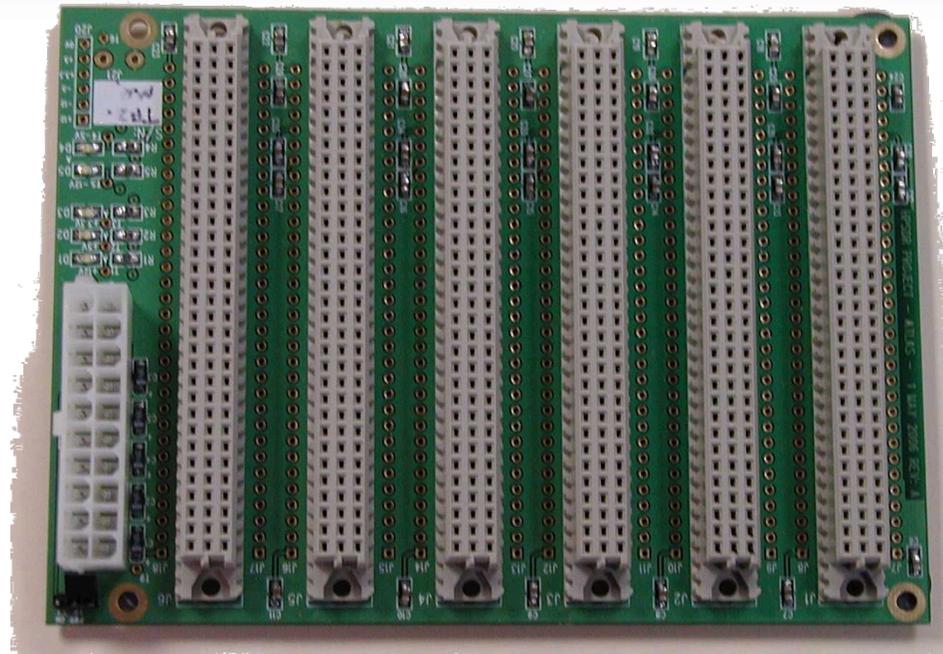


HPSDR

- Open Source Development
 - TAPR OHL, GPL
- Multiple Projects – each a building block for a radio
 - Programmable hardware (FPGA, μ Controllers)
 - Unifying Backplane (ATLAS)
- Advancing the State of the Radio Art
- Core Projects:
 - OZY – Interface
 - Mercury: 1.8 – 55MHz Receiver
 - Penelope: 1.8 – 55MHz Exciter

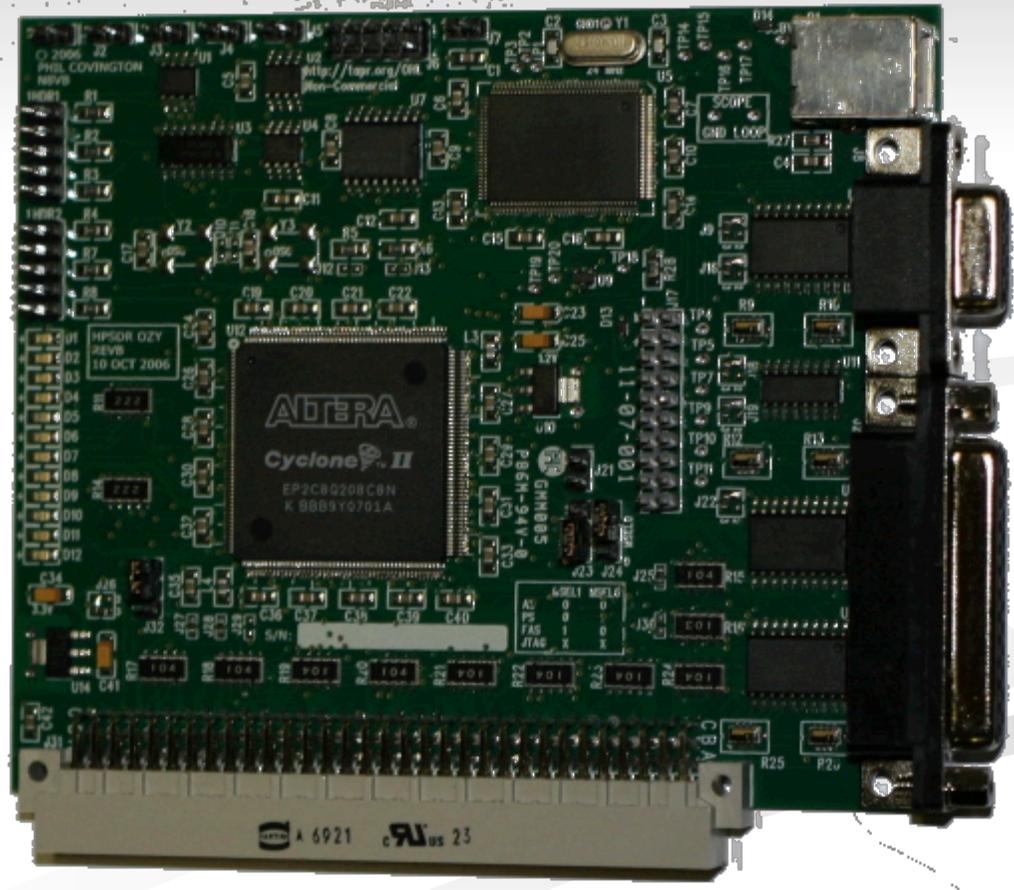
Atlas Backplane

- Six slots
- ATX power supply
- LED Indicators

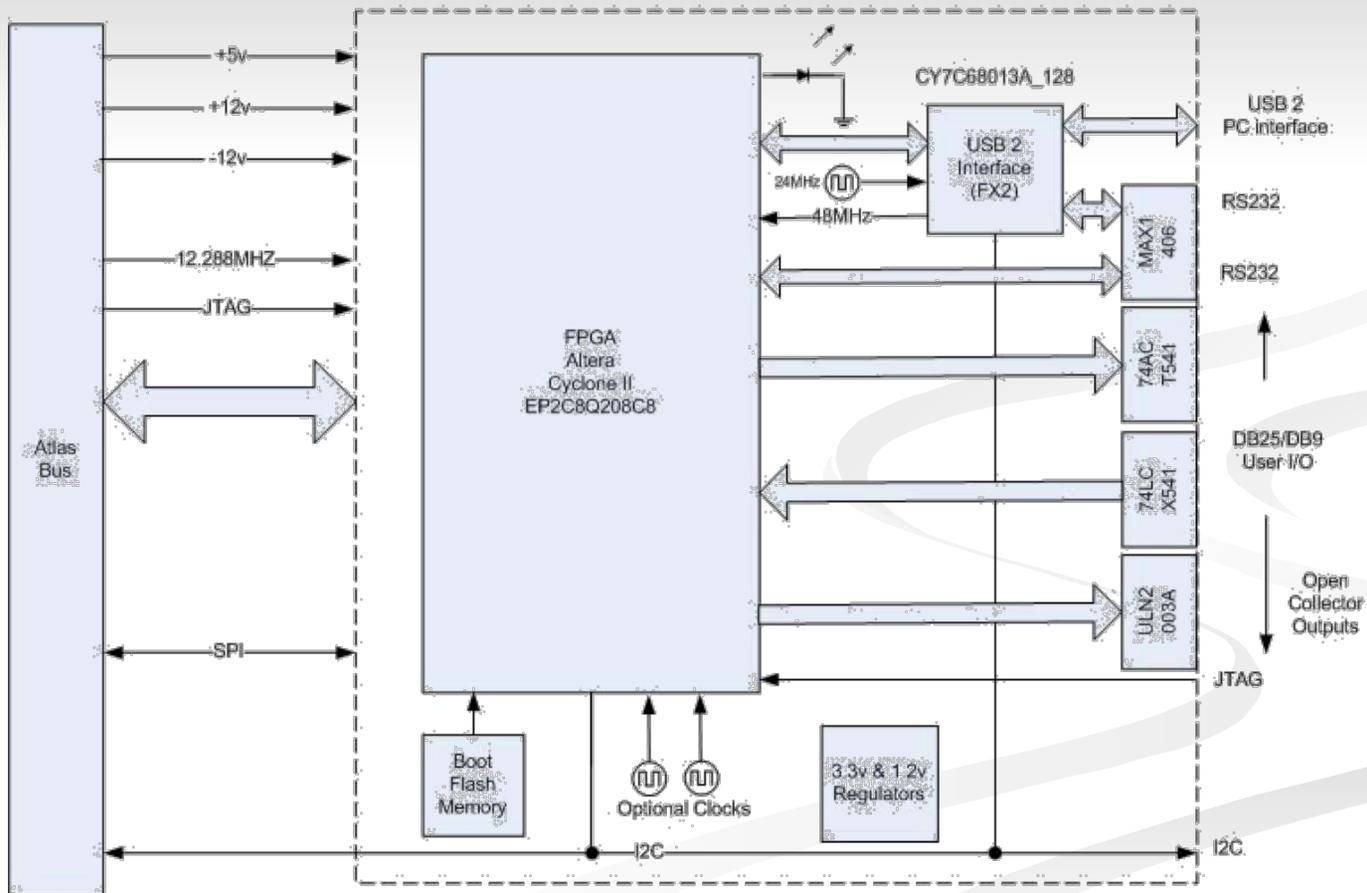


OZY (Ozymandias)

- USB 2.0
- FPGA
- Serial Ports
- Parallel Port
- GPIO Lines
- USB Blaster



OZY Block Diagram

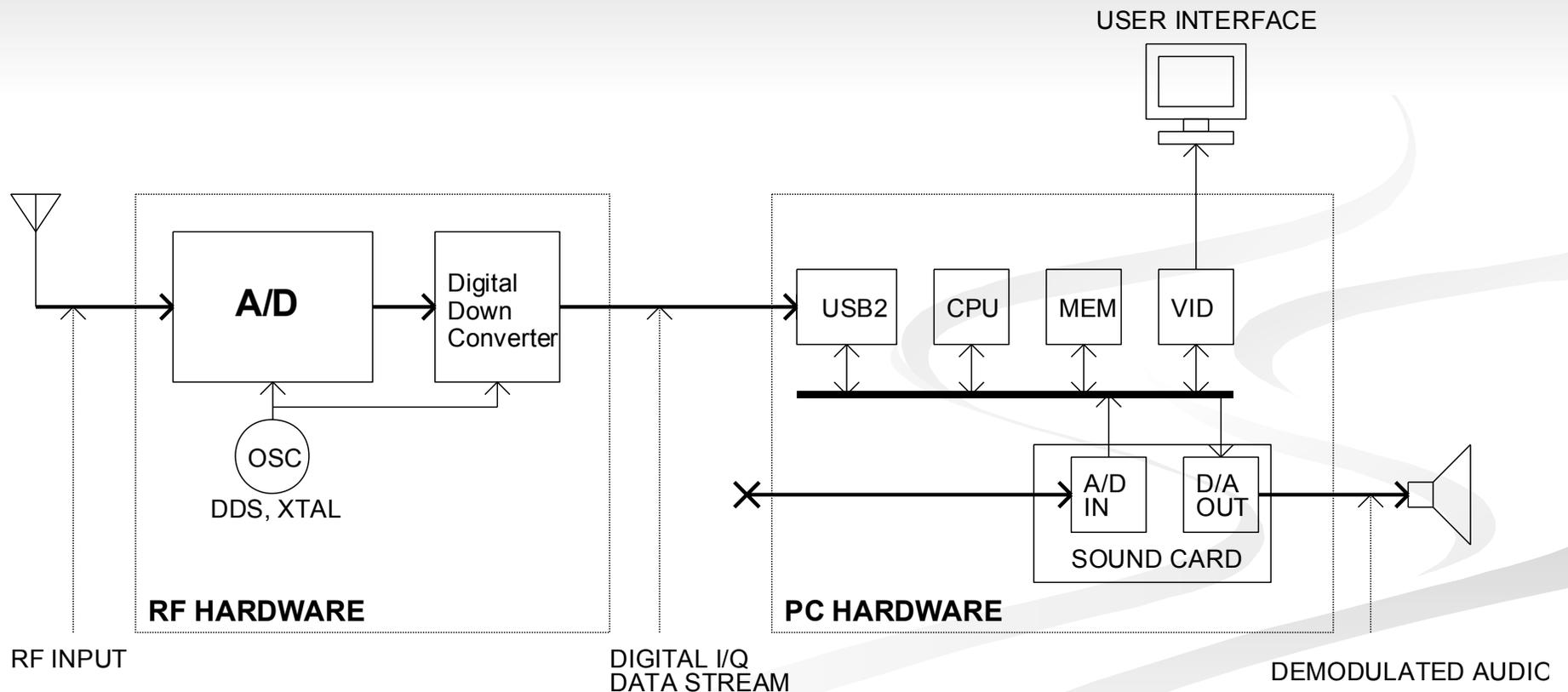


Mercury 0-55MHz Direct Sampling Receiver

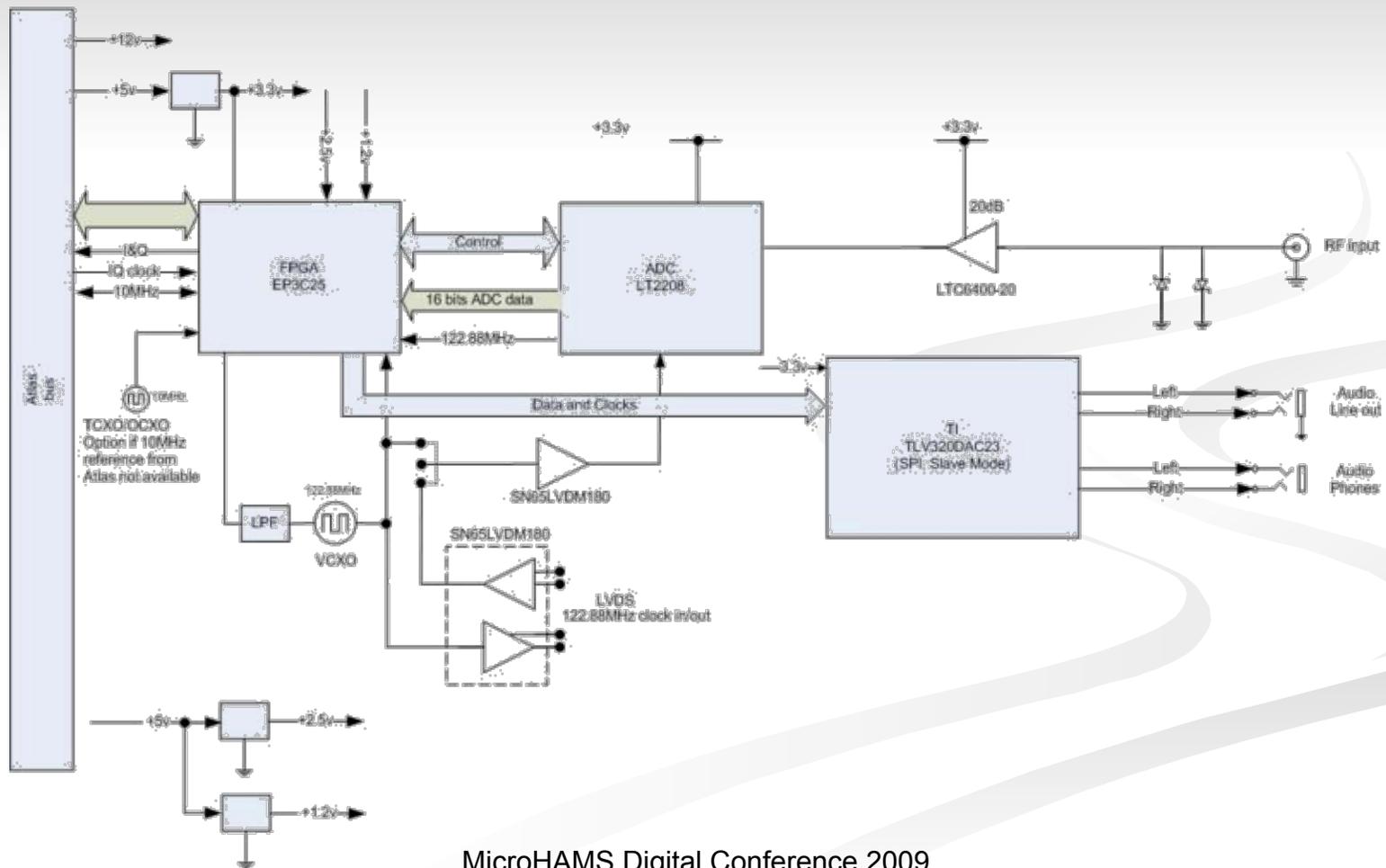
- LT2208 @ 100MHz
 - 1.5v pep
 - SFDR 100dB
 - 200 ohm input
- Off Carrier Rejection
 - 300Hz -110dBc/Hz
 - 2000Hz -139 dBc/Hz
 - 5000Hz -142 dBc/Hz
- Noise Figure 23.4dB
- IP3 46.8 dBm



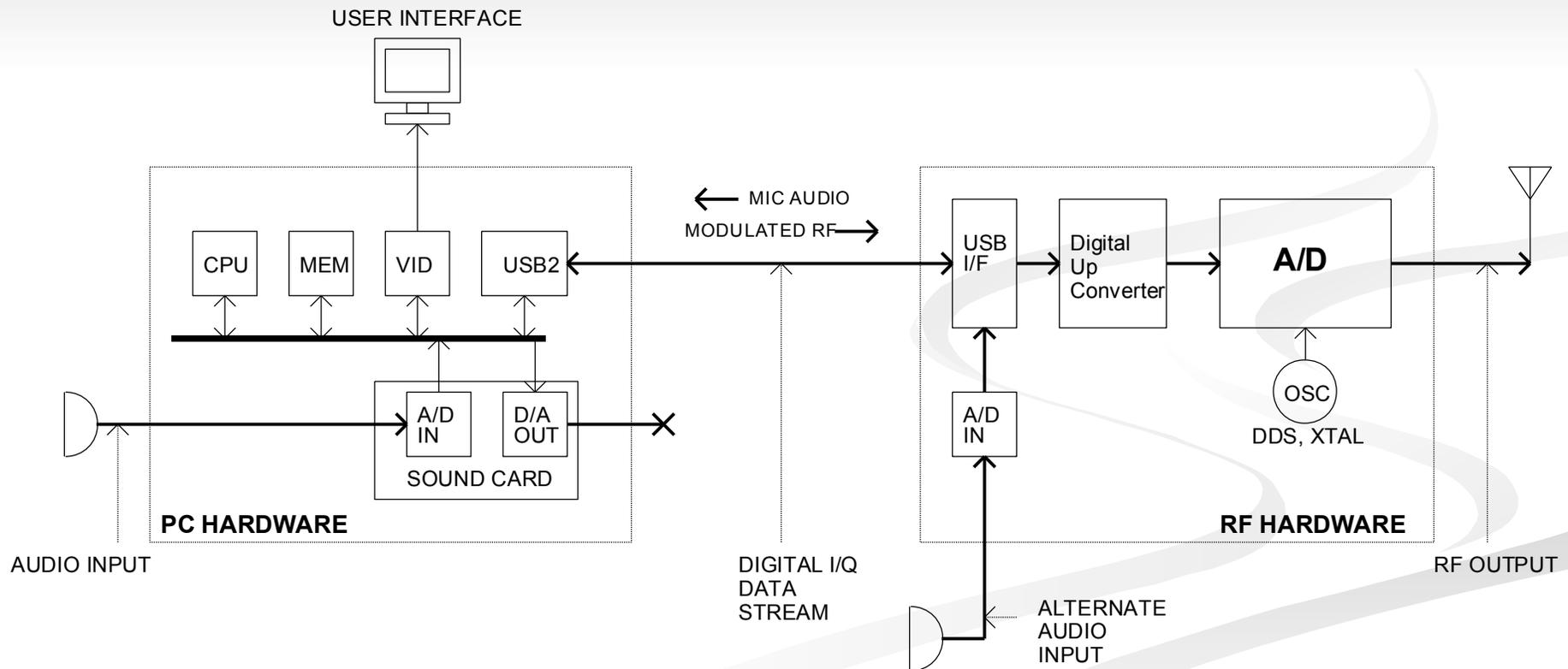
Mercury Simplified Block Diagram



Mercury Block Diagram

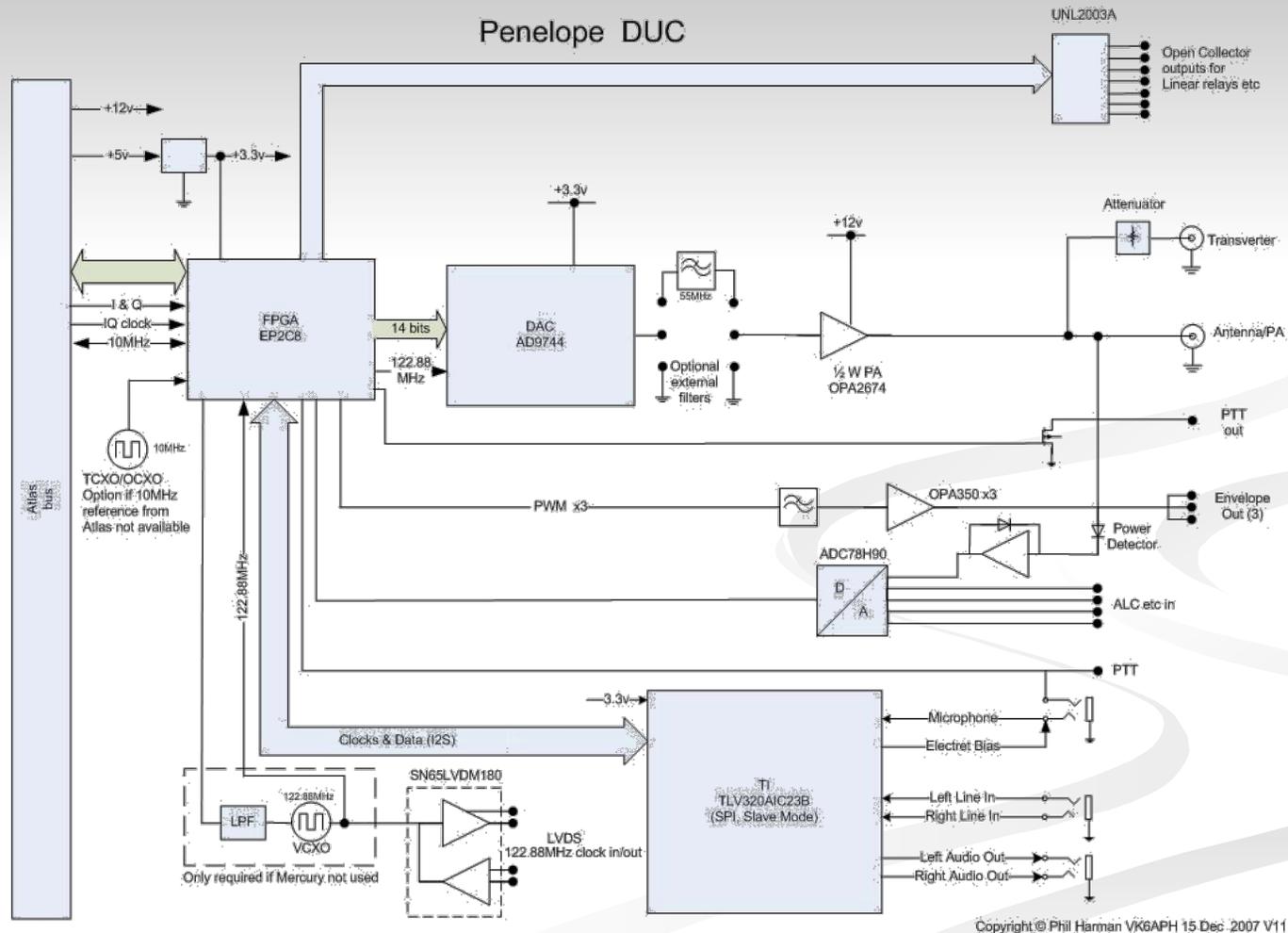


Penelope Simplified Block Diagram



Penelope (DUC) Block Diagram

Direct Up Conversion!



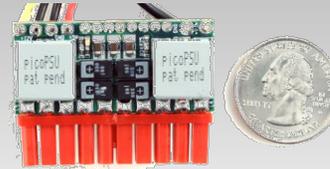
Example Project

- Build an HPSDR HF Transceiver
 - 160m – 10m (6m nice-to-have)
 - 100w
 - 13.8vdc (nice to have)
- Essentially An Integration Effort
 - Three HPSDR.ORG boards
 - Mercury, Penelope, Ozy + backplane
 - Power supply (ATX)
 - RF Power Amplifier
 - Transmit Filter
 - Enclosure

The Search for Missing Items...

- ATX Power Supply

- Pico PSU-120wi-25



- RF Power Amp & Filter

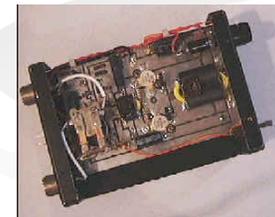
- Several “off-the-shelf” options

- K5OOR 10w PA + home-brew PA and filters
- Communications Concepts kits
- Tokyo Hy-Power (nice but expensive)

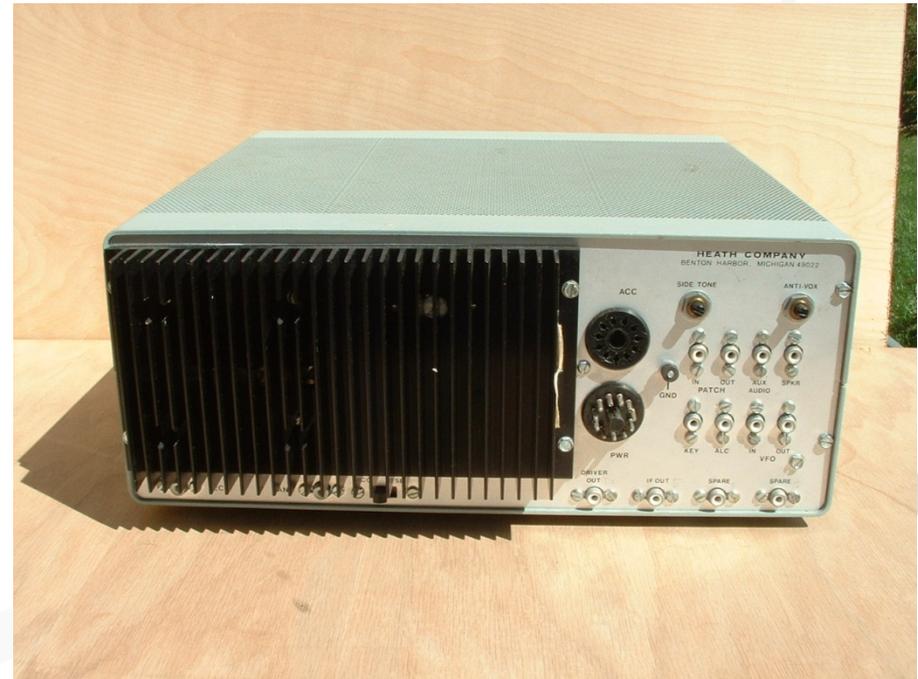
- Junk Box (TS-50s)

- Enclosure

- Various Grey Boxes
- Junk Box... hmmm...



And the Winner Is..



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Idea... Integrate the Controls!

- More Items Required

- Frequency Display

- Delcom 8-digit LED

- AD for Pushbuttons and Potentiometers

- Labjack U3

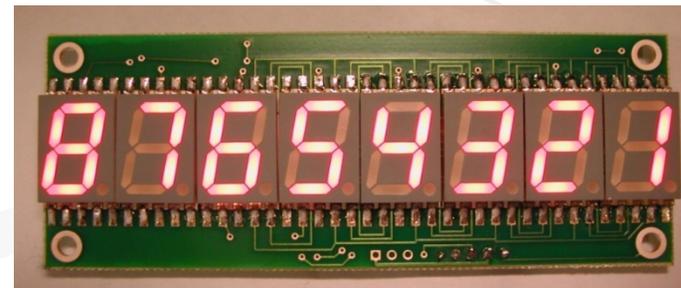
- Encoder for VFO Control

- Griffin PowerMate

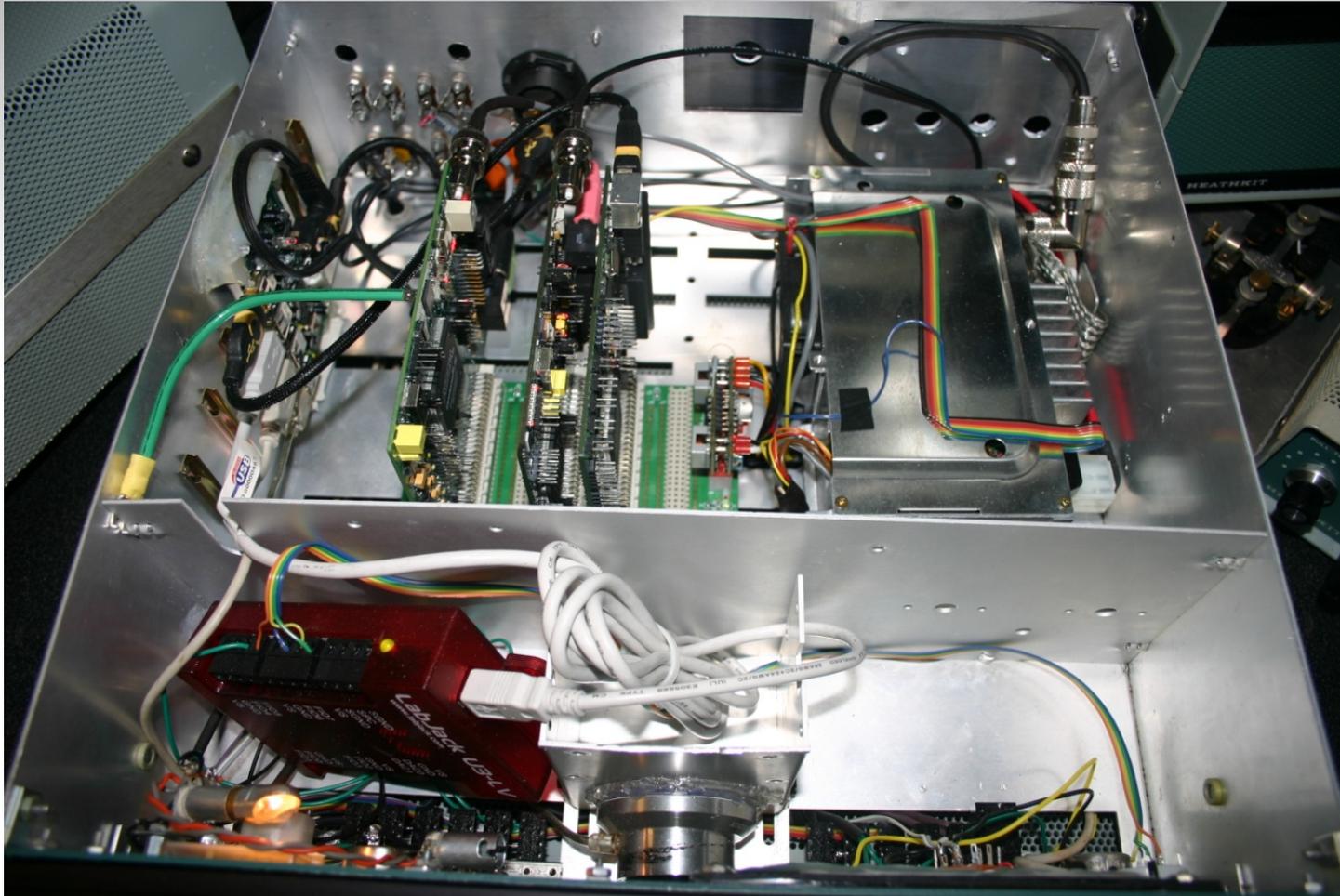
- USB Hub

- Junkbox

- Software Glue



Results...





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Don't Forget The Remote VFO!



HPSDR – The Next Generation!



Resources

- Email

- dquigley@msn.com or n7hq@arrl.org

- Web Resources:

- www.microsoft.com
- www.hpsdr.org
- www.tapr.org
- <http://www.delcom-eng.com>
- <http://www.labjack.com>

Demo

